Reducing Obesity via a School-Based Interdisciplinary Intervention Among Youth

Planet Health

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Objective: To evaluate the impact of a school-based health behavior intervention known as Planet Health on obesity among boys and girls in grades 6 to 8.

Design: Randomized, controlled field trial with 5 intervention and 5 control schools. Outcomes were assessed using preintervention (fall 1995) and follow-up measures (spring 1997), including prevalence, incidence, and remission of obesity.

Participants: A group of 1295 ethnically diverse grade 6 and 7 students from public schools in 4 Massachusetts communities.

Intervention: Students participated in a school-based interdisciplinary intervention over 2 school years. Planet Health sessions were included within existing curricula using classroom teachers in 4 major subjects and physical education. Sessions focused on decreasing television viewing, decreasing consumption of high-fat foods, increasing fruit and vegetable intake, and increasing moderate and vigorous physical activity.

Main Outcome Measures: Obesity was defined as a composite indicator based on both a body mass index and a triceps skinfold value greater than or equal to age- and sex-specific 85th percentiles. Because schools were randomized, rather than students, the generalized estimating equation method was used to adjust for individual-level covariates under cluster randomization.

Results: The prevalence of obesity among girls in intervention schools was reduced compared with controls, controlling for baseline obesity (odds ratio, 0.47; 95% confidence interval, 0.24-0.93; $P = .03$), with no differences found among boys. There was greater remission of obesity among intervention girls vs control girls (odds ratio, 2.16; 95% confidence interval, 1.07-4.35; $P = .04$). The intervention reduced television hours among both girls and boys, and increased fruit and vegetable consumption and resulted in a smaller increment in total energy intake among girls. Reductions in television viewing predicted obesity change and mediated the intervention effect. Among girls, each hour of reduction in television viewing predicted reduced obesity prevalence (odds ratio, 0.85; 95% confidence interval, 0.75-0.97; $P = .02$).

Conclusion: Planet Health decreased obesity among female students, indicating a promising school-based approach to reducing obesity among youth.

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Editor's Note: The difference in outcome for boys vs girls is more proof that the sexes are from different planets. I guess Planet Health is more like Venus than Mars.

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THE PREVALENCE of obesity among children and youth in the United States has increased rapidly over the past 30 years. Obesity is the most common nutritional disorder among these age groups[1-4] and a major cause of excess morbidity and mortality.[5] This rapid increase in prevalence indicates that the Healthy People 2000 objective for adolescent obesity will not be met.[6] Although the origin of obesity is complex and relates to both genetic and environmental determinants, obesity ultimately results from an imbalance of energy intake via diet relative to energy expenditure.[5] Both energy intake and energy expended via physical activity are substantially discretionary and hence the foci of intervention.

It is not clear how changes in dietary intake or changes in activity levels have contributed to recent increases in obesity.[7] Television viewing has been cited as one cause of increasing prevalence, based on both longitudinal[8,9] and cross-sectional studies.[10,11] The impact of television viewing on obesity is most likely due to both the displacement of more vigorous activities by television and effects on diet.[8,12] Foods are the most heavily advertised products on

SUBJECTS AND METHODS

Planet Health interventions occurred in 5 schools located in 4 communities in the Boston, Mass, metropolitan area; the 5 control schools were located in the same communities. Recruitment of school systems to participate was based on their willingness to implement the classroom and physical education (PE) interdisciplinary curriculum, a multiethnic student population, and cooperation with random assignment of schools to the intervention or control condition.

Informed consent procedures were followed for all students. Five schools required an active consent procedure for the survey and physical measurements; parents (or guardians) needed to return a form regardless of whether they wanted their child to participate. The remaining schools used a passive consent procedure: a letter was sent to all parents describing the project, with the option to sign and return the form if they did not want their child to participate. The 5 schools with active consent included 56% of potential participants in intervention schools and 36% of potential participants in control schools. Forms were translated into 7 languages. The study was approved by the Committee on Human Subjects at the Harvard School of Public Health.

DESIGN

In 1995, 10 schools from 4 communities were randomly assigned (using a random number table) to either intervention (n = 5) or control (n = 5) status. Prior to randomization, we matched schools by town (pairs of schools within 4 towns were matched) or school size and ethnic composition (1 pair matched from 2 adjacent towns) to balance factors that could affect study outcomes, such as school food services, health-related curricula, or PE. The median household income of zip code areas where the schools were located averaged $36 020 among intervention schools and $34 200 among control schools, according to 1990 Census data. This median is lower than that for all households in Massachusetts in the 1990 Census ($41 000) but similar to the US figure ($33 952).[21]

Student intervention status was assigned based on school enrollment in fall 1995. All students in intervention schools in grades 6 and 7 in 1995 were exposed to intervention components. Youths who continued at an intervention school in the following year received 2 school years of intervention. Control schools received their usual health curricula and PE classes and none of the Planet Health program.

The primary study contrast was between students in the intervention and control schools with respect to changes from baseline (fall 1995) to follow-up (spring 1997). The primary end point at the individual level was obesity; secondary end points included self-reports of television viewing, moderate and vigorous physical activity, percent of total dietary intake from fat, servings of fruits and vegetables, and total energy intake.

Anthropometry data and student surveys were collected at the beginning of grades 6 and 7 in fall 1995, and follow-up measurements on this cohort were collected in spring 1997 (grades 7 and 8). Because obesity[22] and dietary and activity patterns vary seasonally, data were collected at the same time for both intervention and control participants. Therefore, the difference in season of measurement for baseline and outcome variables should not bias estimates of intervention effect.

THE PLANET HEALTH INTERVENTION

Theoretical Framework

Planet Health was designed to reduce obesity by increasing energy expenditure while promoting key dietary behaviors consistent with dietary guidelines.[23] The intervention focused on 4 behavioral changes: reducing television viewing to less than 2 hours per day[24]; increasing moderate and vigorous physical activity; decreasing consumption of high-fat foods; and increasing consumption of fruits and vegetables to 5 a day or more.[23]

We used concepts from behavioral-choice and social-cognitive theories of individual change, with a distinctive focus on reducing television viewing. Clinical research in behavioral-choice theory indicates that reducing sedentary time coincident with a dietary intervention can decrease obesity among youths who are obese.[25] Other studies indicate that choice of vigorous activity among children can be enhanced by decreasing access to sedentary activities and improving access to vigorous activity,[26] with similar results shown for eating behavior.[27] By allowing children choice over alternative activities when television viewing time is reduced, their perceived sense of control over physical activity alternatives is increased, and this can reinforce physical activity.[28] Participants in Planet Health were encouraged to "make space" for more activity in their lives by reducing television time. Both the activity and dietary components of the intervention were designed to emphasize "lifestyle" changes in behavior. Although increased fruit and vegetable consumption has not been related to obesity prevalence, a reduction in high-fat foods coupled with the motivation to try less energy-dense fruits and vegetables could reduce obesity risk.

Social-cognitive theory[29] points to the importance of social and environmental factors that influence both psychosocial and behavioral risk factors[30,31] for obesity. Prior school-based interventions grounded in social-cognitive theory have produced modest reductions in dietary fat intake and increases in physical activity[32-35] but little evidence for change in obesity[19,20] and no evidence for reductions in television viewing. Planet Health was designed to provide students with cognitive and behavioral skills to enable change in target behaviors, practice using skills to strengthen perceived competence in employing new behaviors effectively, and support for behaviors by multiple classroom and PE teachers.

A distinctive aspect of Planet Health is the interdisciplinary curriculum approach,[36] with intervention material infused into major subject areas and PE, using grade- and subject-appropriate skills and competencies. This approach is designed to enhance efficiency by using classroom teachers with minimal health education training to implement the materials, and to enhance effectiveness by involving multiple classes, which often use different approaches to learning.[37] Teacher training sessions were developed to enhance implementation.[38]

Planet Health focused on improving the activity and dietary behaviors of all students, without singling out youths who were obese for attention. This population-based approach focuses on changing the distribution of obesity in the population[17] by both reducing obesity among those already obese (remission) and preventing new cases. The population approach also limits the risk of stigmatizing obese students.[39]

Intervention Components

Each intervention school received the Planet Health program of teacher training workshops, classroom lessons, PE materials, wellness sessions, and fitness funds. All teachers received training from project staff either in workshops (all PE teachers, two thirds of classroom teachers) or with the field coordinator. Based on teacher interests, an average of 3 teacher/staff wellness sessions were offered per school, provided at low cost by outside organizations.

Planet Health materials incorporate standards outlined in the Massachusetts Curriculum Frameworks,[40] so that skills and competencies that are required learning in middle school are used as vehicles for conveying Planet Health messages. In classroom lessons, each theme was addressed in 1 lesson per subject (language arts, math, science, and social studies), for a total of 16 core lessons each in year 1 and year 2 (32 total). An additional lesson developed a 2-week campaign to reduce television viewing in households ("Power Down"). Lessons consisted of teacher resources; behavioral and learning objectives; procedure, extension, or homework activities; and student resources and handouts. Each classroom lesson had a behavioral objective that fit with 1 of the 4 behavioral targets of the intervention.

Units were developed with extensive teacher input via lesson evaluations and focus groups using a variety of innovative, student-centered teaching methods to engage students, including demonstrations, debates, case studies, group projects, games, and student presentations. Classroom lessons were designed for one or two 45-minute periods, depending on the level of detail chosen by teachers.

Physical education materials focused on activity and inactivity themes and included student self-assessments of activity and inactivity levels and goal setting and evaluations for reducing inactivity, replacing inactive time with moderate and vigorous physical activities of their choosing. Lessons were organized into thirty 5-minute microunits that were designed to be repeated with extensions in school-year 2; the first 5 microunits focused on Fit-Check self-assessments and goal setting. Fitness Funds were monetary incentives of \$400 to \$600 provided to intervention schools in response to teacher-submitted proposals consistent with Planet Health themes.

Outcome Measures

Primary End Point—Obesity. Student height without shoes was measured to the nearest 0.1 cm using a Shorr stadiometer (Shorr Productions, Olney, Md) and weight in light clothes was measured to the nearest 0.1 kg on a portable electronic scale (Seca Model 770; Seca Scale Corp, Munich, Germany) calibrated using the Seca standard weights step-up test. Triceps skinfolds (TSF) were measured to the nearest 0.2 mm using calibrated Holtain calipers. Measurements were obtained by trained project staff and standardized according to accepted protocols[41] that were modified for administration in a public school setting. Replicate measures of TSF were obtained to improve precision; if the 2 measurements differed by more than 2 mm, a third measurement was taken. Analyses used the average of the measures.

We defined obese students using a composite indicator[42,43] based on both a body mass index (BMI, kg/m^2) and a TSF measure greater than or equal to the 85th percentile of age- and sex-specific reference data.[44] Secular increases in child and adolescent obesity in the past 2 decades have been documented with indicators based on either TSF[1,2] or BMI.[3,4] Research has indicated, however, the limitations of using only BMI or only TSF as an obesity indicator. Among children and youth, the BMI correlates well with laboratory measures of the total and percent body fat,[45,46] but differences are noted by sex, race/ethnicity, and maturation.[43,47,48] The BMI has been shown to be highly specific in identifying adolescents with a high percentage of body fat, but it has low sensitivity.[48] Furthermore, BMI is not a direct measure of total or percent body fat but is influenced by frame size. Changes in BMI may reflect lean body mass rather than fatness.[49] Triceps skinfolds constitute a direct, valid measure of adiposity[45,50] with substantial reliability,[51] although unreliability tends to increase among the most overweight individuals,[52] and TSF may not reflect differences in subcutaneous fat distribution that vary by racial/ethnic group and sex.[47,53]

Recent guidelines on consensus indicators that addressed these methodological issues in both domestic[42] and international[43] settings recommend a combination of indicators. One recommended composite indicator for this purpose is based on 3 measures: BMI, TSF, and subscapular skinfolds[43] relative to reference standards.[44] We were unable to secure approval to obtain subscapular skinfold measurements in a school setting. The composite indicator we selected to classify obesity in our multiethnic school-based sample, BMI and TSF at or above the 85th percentile, addresses methodological concerns related to indicators based on either measure alone. The combination of BMI and TSF is designed to distinguish individuals who are overweight but not overfat from the truly obese.

Sexual maturity ratings are recommended to interpret and control for differences among individuals in early and later maturational tempo that are not reflected in reference growth curves for BMI and TSF.[43,47,54] In this research setting, we obtained self-reports of menarcheal status and age at menarche among girls. Use of self-reported or clinical sexual maturity ratings was not permitted by the school systems.

Food and Activity Survey. *Television, Activity, and Diet Measures*. Measures of television viewing, physical activity, and dietary intake as well as other sociodemographic and behavioral variables were obtained via an optically scannable student Food and Activity Survey. Students completed the Food and Activity Survey independently in class under the supervision of teachers who participated in hour-long training sessions prior to administration.

Television and Video. Hours of television and video viewing were assessed with an 11-item Television and Video Measure. Questions asked about hours of television typically viewed during each day of the week as well as use of videocassette recorders and video and computer games. Items were appropriately weighted and summed to obtain a total hours-per-day viewing estimate. Studies have indicated high test-retest reliability of youth self-reports of television viewing.[55] We selected a random sample of 53 students who underwent two 24-hour physical activity

Continued on next page

recalls administered by trained interviewers 1 month apart, as well as the Food and Activity Survey. We found a deattenuated[56] correlation of television viewing assessed by the Television and Video Measure with 24-hour recall of $r = 0.54$, with equivalent means.

Physical Activity. Moderate and vigorous physical activity levels were assessed using a Youth Activity Questionnaire, which contains 16 items that estimate hours per day spent in moderate and vigorous activities (≥3.5 metabolic equivalents)[57] over the past month. Walking was not included because of low validity found for this domain.[58] The Youth Activity Questionnaire was adapted from a 14-item physical activity questionnaire demonstrated to have excellent reproducibility and validity in adults.[59,60] In the repeat 24-hour validation sample, the Youth Activity Questionnaire was correlated (deattenuated[56]) with 24-hour recall at $r = 0.80$, with equivalent means.

Dietary Intake. Assessment of intake of fruits and vegetables, percentage of energy from fat and saturated fat, and total energy intake (in kJ) was made using the Youth Food Frequency Questionnaire, which has been adapted and validated for use in ethnically and socioeconomically diverse populations.[58,61,62] To be consistent with National Cancer Institute nutrition education guidelines, when calculating fruit and vegetable intake, we excluded french-fried potatoes.[63] We excluded observations with implausible daily energy intakes (≤2100 or ≥29 000 kJ; less than 1% of observations) in dietary analyses.

Sociodemographic Variables. Age was calculated based on birth date and date of examination, except for a few cases in which the birth date was missing and Food and Activity Survey data were used. Sex was classified at the time of examination by measurers; in the few cases in which sex data were missing, school-list data were used. Ethnic categories were based on responses of students to a question asking them to mark all that apply: "How do you describe yourself?" The response categories were white, black, Hispanic, Asian or Pacific Islander, American Indian or Alaskan Native, and other. Participants checking "black" were classified as African American.

Other Survey Variables. Self-reports of weight-loss behavior were adapted from national surveillance indicators,[64] including dieting to lose weight, exercising to lose weight, vomiting or taking laxatives to lose weight, and taking diet pills to lose weight, and have been associated with adolescent overweight in a multiethnic sample.[65]

Implementation Measures. We used teacher reports of implementation, which have shown good validity compared with classroom observations.[66]

Statistical Methods

Because schools, not students, were randomized, the generalized estimating equation method[67] for analysis of dichotomous outcomes was used to adjust for individual-level covariates under cluster randomization, with schools nested within experimental conditions, using software written for use with SAS data sets (SAS Inc, Cary, NC).[68] This approach takes into account the intraclass correlation of responses within schools. The generalized estimating equation analysis also took into account the school matching in the design, including indicator variables for randomization pairs.[69] Separate regressions were estimated for boys and girls because of different patterns of incremental growth in weight and height relative to skinfold velocities and differences in maturational tempo between boys and girls.[43,47,48] We controlled for ethnic category because of different patterns of BMI and TSF among ethnic groups.[44,47] In regressions to predict obesity at follow-up, we controlled for intervention status, indicators for randomization pairs, and known baseline predictors of obesity, including obesity, age, ethnic category, TSF, and BMI. We then tested to see if any of the following theoretically relevant variables measured at baseline added significantly to the regression equations ($P < .05$): menarcheal status, cigarette smoking, dietary total energy intake per day, percentage of total energy from total and saturated fat, Television and Video Measure score, hours of daily moderate and vigorous physical activity, weight-loss behaviors, and behavioral intentions to walk more, exercise more, or watch less television. Exercising to lose weight, the only variable that significantly contributed to the equation for girls, was added to the female regression models. None of the variables contributed to the male regression models.

Similar regressions were estimated to predict changes in behavioral measures (eg, Television and Video Measure). For analysis of these continuous outcomes, we used SUDAAN software (Center for Information Technology, National Institutes of Health, Bethesda, Md) to similarly estimate regressions under cluster randomization, and control for the pair-matched design; SUDAAN estimates use an implicit Taylor linearization method.[68]

Analyses were conducted using an intention-to-treat protocol, with participants analyzed in their original randomized condition irrespective of the number of Planet Health sessions attended.[70]

To assess the extent to which intervention effects could be attributed to significant changes in behavioral variables, we reestimated regressions predicting obesity change and controlled for both the baseline behavioral variable and change in that variable from baseline to follow-up. We examined Television and Video Measure scores, fruit and vegetable intake, and total energy intake.

We used indicator variables with mean substitution to control for missing behavioral data (<5%). Because of potential bias with this approach,[71] we also reestimated regressions that excluded observations with missing data. Both approaches produced similar results. In regressions estimating change in fruit and vegetable consumption, we energy-adjusted results by controlling total energy intake via linear regression.[72]

By design, the anthropometric measures worked in both intervention and control schools, blind to intervention status, but because of scheduling logistics, 5 of the measurers[29] were not perfectly balanced. To determine if these differences affected study results, we reestimated logistic regressions that predicted obesity change, adding indicators for measurers. The outcome results were unchanged.

children's television,[13] and television viewing time is associated with between-meal snacking.[14] Experimental and observational studies indicate the effects of exercise on body fat reduction.[15] Some studies indicate a potential effect of dietary fat on the prevalence and treatment of obesity.[5,11] The only interventions that have shown long-term effectiveness in reducing obesity have been intensive clinical programs for obese children.[16] These programs require parental participation and focus on modifications in both diet and physical activity.

The rapidly increasing prevalence of obesity in the United States, however, may require a more population-based effort, in contrast to interventions focused only on high-risk (eg, already obese) individuals.[17] Interventions focused on reducing obesity prevalence among young children and adolescents may be particularly important because the risk of adult obesity is increased markedly if one is obese during adolescence.[18] Schools are a potentially important channel of intervention because they offer access to large populations of students and provide the opportunity to institutionalize programs in communities; however, limited school-based research has focused on reducing obesity among adolescents. School-based interventions targeting obesity have generally treated obese students, with 6 studies indicating some effectiveness.[19] School-wide interventions among adolescents, in contrast, have not focused on reducing obesity but rather on reducing cardiovascular risk and have demonstrated little impact on obesity.[19,20]

Planet Health is a school-based intervention designed to reduce obesity in middle-school youth (grades 6-8) by altering key physical activity and dietary risk factors, including reductions in television viewing. The intervention was included within existing classes in schools to limit cost and improve replicability, beginning when students were in grades 6 and 7 and continuing over 2 school years. In our article, we describe the impact of Planet Health on obesity prevalence among boys and girls.

RESULTS

PARTICIPATION, FOLLOW-UP, AND BASELINE CHARACTERISTICS

At baseline in fall 1995, both anthropometry and Food and Activity Survey data were collected from 1560 students in grades 6 and 7 in the 10 intervention and control schools. The overall participation rate was 65% of eligible students (64.5% in control and 64.8% in intervention schools). We excluded students on school lists who transferred schools at baseline, were in special education classes, or were in the wrong grade. We classified as nonparticipants the 5% of eligible students who completed a Spanish-language version of the questionnaire. Consent rates were 58% among schools with active consent and 89% among schools with passive consent.

Baseline data stratified by sex revealed no significant differences among the 1560 intervention and control students in mean values of age, BMI, TSF, or obesity prevalence. There were some differences in ethnic composition; higher percentages of African American girls (17% vs 10%) and Hispanic boys (18% vs 12%) in control schools. No differences were seen for other ethnic categories by sex. Major reasons for nonparticipation in baseline anthropometry were lack of parental consent (80% of those not participating) and absence from school (14% of those not participating).

Outcome anthropometric data were collected 2 school years later, in spring 1997, for 83% of the baseline sample. For girls, follow-up data were obtained for 82% of control and 81% of intervention students; for boys, rates were 86% and 83%, respectively. Among girls, there were no significant differences in rates of follow-up at baseline. For boys who were obese, a lower rate of follow-up was observed in the intervention condition (87% vs 94% in the controls). Main reasons for lack of follow-up anthropometric data included school transfer (52%), school absence (27%), and child refusal (10%).

For analysis of primary outcomes, the Planet Health cohort was defined as those students with both baseline anthropometry and survey data and follow-up anthropometry (n = 1295). **Table 1** presents the baseline characteristics of cohort participants in fall 1995. Intervention and control participants had similar baseline sociodemographic characteristics, anthropometric data, diet, and physical activity, although some small differences remained. The prevalence of obesity was 28% in control and 27% in intervention students. Among girls, there was a difference in the prevalence of African American students (16% control vs 10% intervention).

PROGRAM IMPLEMENTATION

Eighty-seven percent of the classroom teachers (n = 86) and 100% of the PE teachers (n = 9) completed first-year training sessions. Classroom teacher lesson evaluations (N = 230) indicated that they completed, on average, 3.5 lessons for the year. Teachers were expected to do a minimum of 4 lessons, and "Power Down" could be one of these. Physical education teachers completed, on average, 8.2 microunits during the year. Implementation of microunits was influenced by when the units were started during the school year, teacher motivation, and the fact that some schools had fewer PE classes (once a week or less). Qualitative data collected from teachers indicated that schools varied in the ease with which Planet Health materials were implemented. Schools experienced with interdisciplinary curricula found it easier to implement the materials.

PRIMARY OUTCOME

Obesity

Obesity prevalence among female students in the control schools increased from 21.5% to 23.7% over the 2 school-year intervention periods, while in the intervention schools prevalence declined from 23.6% to 20.3% (**Table 2**). After controlling for baseline covariates, obesity prevalence among female students in the intervention schools was significantly reduced compared with female students in the control schools (odds ratio [OR], 0.47; 95% confidence interval [CI], 0.24-0.93; *P* = .03). Among boys, obesity declined among both control and intervention students. After controlling for covariates, there was no significant difference in outcome (OR, 0.85; 95% CI, 0.52-1.39; *P* = .48).

Adjusted analyses of obesity incidence and remission indicated significantly greater remission for female students who were obese in intervention vs control schools

Table 1. Baseline Characteristics of a Longitudinal Study Sample of Sixth and Seventh Grade Students in Fall 1995, With Anthropometric Data in Spring 1997, at Intervention (I) and Control (C) Schools*

	Students		Girls		Boys	
Characteristic	I (n = 641)	C (n = 654)	I (n = 310)	C (n = 317)	I (n = 331)	C (n = 337)
Background						
Age, y†	11.7 (0.7)	11.7 (0.7)	11.6 (0.7)	11.6 (0.7)	11.8 (0.7)	11.8 (0.8)
Female, %	48	48	. . .	. . .	. . .	. . .
Ethnicity, %						
White	69	63	72	63	67	63
African American	11	15	9	16	12	13
Hispanic	11	16	10	15	12	17
Asian/Pacific Islander	9	7	8	7	9	7
American Indian	2	2	2	2	2	1
Other	5	9	7	9	4	8
Anthropometric Data						
Obese, %‡	27	28	24	22	29	35
Height, cm†	152 (8.3)	152 (8.4)	152 (7.8)	152 (7.7)	151 (8.7)	152 (9.0)
Body mass index†	20.6 (4.5)	20.7 (4.0)	20.8 (4.6)	20.6 (4.2)	20.5 (4.4)	20.8 (3.9)
Triceps skinfolds†	16.0 (7.2)	15.9 (6.9)	16.9 (6.8)	16.4 (6.7)	15.2 (7.6)	15.5 (7.0)
Body mass index ≥85th percentile	34	37	32	32	35	43
Triceps skinfolds ≥85th percentile	30	32	26	25	34	40
Females who had completed menarche, %	. . .	. . .	28	35	. . .	. . .
Baseline Dietary/Activity Variables						
Television/video, h/d†	3.4 (2.2)	3.5 (2.2)	3.0 (2.1)	3.1 (2.2)	3.8 (2.3)	3.8 (2.2)
Moderate/vigorous activity, h/d†	2.2 (1.6)	2.1 (1.6)	1.8 (1.4)	1.7 (1.4)	2.5 (1.7)	2.5 (1.6)
Energy from fat, %†	31.7 (5.2)	31.3 (5.7)	31.3 (5.2)	31.1 (6.0)	32.1 (5.2)	31.5 (5.5)
Energy from saturated fat, %†	10.9 (2.4)	10.8 (2.6)	10.7 (2.4)	10.6 (2.6)	11.2 (2.3)	11.1 (2.6)
Fruit and vegetables, servings/d†	3.7 (2.7)	4.2 (2.8)	3.4 (2.4)	4.2 (2.8)	4.0 (2.9)	4.1 (2.8)
Total energy intake, J/d†	8597.4 (4393.2)	8849.4 (4750.2)	7555.8 (3423.0)	8034.6 (4128.6)	9580.2 (4956.0)	9626.4 (5161.8)
Smoked in last month, %	1	4	1	3	1	5
Physical education, times/wk‡	1.7 (0.6)	2.0 (1.1)	1.6 (0.6)	2.0 (1.1)	1.7 (0.6)	2.0 (1.2)
Knowledge						
Dietary knowledge†	11.4 (3.5)	11.2 (3.6)	12.0 (2.9)	12.0 (3.2)	10.8 (3.9)	10.5 (3.9)
Activity knowledge†	6.9 (1.9)	6.9 (1.8)	7.3 (1.3)	7.3 (1.5)	6.4 (2.2)	6.5 (2.0)
Dieting Behavior						
Diet to lose weight, %	26	30	29	32	23	29
Exercise to lose weight, %	44	43	47	43	41	42
Vomit/take laxatives, %	4	6	2	4	6	7
Take diet pills, %	3	3	2	2	4	4

*Sample size vary slightly due to missing data.
†Values are expressed as mean (SD).
‡Obesity was measured by body mass index and triceps skinfold greater than or equal to the 85th percentile.

(OR, 2.16; 95% CI, 1.07-4.35; $P = .04$) and no difference for boys (OR, 1.37; 95% CI, 0.44-4.24; $P = .54$).

Although school-specific analyses were limited by small samples, an examination of change in adjusted obesity rates by school indicated positive evidence for intervention effect among girls in 4 of the 5 pairs of schools.

SECONDARY OUTCOMES

Behavioral Change

We examined evidence for impact of the intervention on the 4 behavioral targets of Planet Health as well as total energy intake. Both crude and adjusted changes in these measures are displayed in **Table 3**, stratified by sex. After adjusting for baseline covariates, the number of television hours per day among girls was reduced in the intervention schools compared with students in control schools (−0.58 hours; 95% CI, −0.85 to −0.31 hours; $P = .001$). Likewise among boys, there was evidence for a reduction in television time among intervention students compared with controls (−0.40 hours; 95% CI, −0.56 to −0.24 hours; $P < .001$). Among girls, there was less of an increase in estimated energy intake per day over the 2 school years among intervention participants compared with controls (−575 J; 95% CI, −1155 to 0 J/d; $P = .05$) and an increase in fruit and vegetable consumption (0.32 servings/d; 95% CI, 0.14-0.50 servings/d; $P = .003$). There was no evidence for statistically significant changes in the other measures.

Behavioral Variables as Explanations for Intervention Effect

We hypothesized that change in behavioral variables (television viewing, fruit and vegetable consumption, and energy intake) could explain the intervention effect among girls. Regression results indicated that only change in tele-

Table 2. Estimated Change in Obesity From Baseline to Follow-up for Children in Planet Health Intervention vs Control Schools, 1995 to 1997*

Measure	Sample	Baseline, %†	Follow-up, %†	Crude Change, %	Crude Odds	Adjusted Odds‡	95% Confidence Interval	P
Female Obesity								
Prevalence, %								
Control	317	21.5	23.7	+2.2	1.00	1.00	0.24-0.93	.03
Intervention	310	23.6	20.3	−3.3	0.59	0.47		
Incidence, %								
Control	249	. . .	8.0	+8.0	1.00	1.00	0.23-2.38	.57
Intervention	237	. . .	5.5	+5.5	0.66	0.77		
Remission, %								
Control	68	. . .	19.1	−19.1	1.00	1.00	1.07-4.35	.04
Intervention	73	. . .	31.5	−31.5	2.00	2.16		
Male Obesity								
Prevalence, %								
Control	337	34.7	31.8	−2.3	1.00	1.00	0.52-1.39	.48
Intervention	331	29.3	27.8	−1.5	0.97	0.85		
Incidence, %								
Control	220	. . .	9.6	+9.6	1.00	1.00	0.71-1.75	.58
Intervention	234	. . .	7.7	+7.7	0.79	1.12		
Remission, %								
Control	117	. . .	26.5	−26.5	1.00	1.00	0.44-4.24	.54
Intervention	97	. . .	23.7	−23.7	0.86	1.37		

*Restricted to cohort students with paired data.
†Baseline and follow-up values are the unadjusted percentages.
‡Adjusted odds control for baseline obesity as well as other baseline covariates, including intervention status, age, ethnicity, indicators for randomization pairs, and baseline measures of triceps skinfolds and body mass index. For girls, a variable indicating that the student reported exercising to lose weight at baseline was added to the regressions. Regression estimates were calculated using the generalized estimating equation method to account for cluster randomization.

vision viewing mediated the intervention effect. When included in the regression predicting change in obesity along with baseline television viewing, each hour of reduction in television viewing was independently associated with a reduction of obesity prevalence (OR, 0.85; 95% CI, 0.75-0.97; $P = .02$), and the intervention effect was then only marginally statistically significant ($P = .08$, regression not shown).

Among girls who were obese at baseline, when we controlled for baseline television viewing and change in television viewing, each hour of reduction in television viewing was independently associated with increased remission of obesity (OR, 1.92; 95% CI, 1.37-2.70; $P = .002$), and the estimate of intervention effect was reduced (adjusted OR, 2.4-1.6) and was not statistically significant ($P = .17$).

Change in Obesity by Ethnic Group

We examined evidence for reductions in obesity among different ethnic groups, with samples large enough to estimate obesity rates (a minimum cell size of 5), although for all groups other than whites the numbers were small. The largest intervention effects were seen among African American girls, with obesity prevalence significantly reduced in intervention vs control participants (OR, 0.14; 95% CI, 0.04-0.48; $P = .007$). The intervention effect among white girls was similar to the overall result (OR, 0.46; 95% CI, 0.19-1.12; $P = .08$). Among Hispanic girls, results were statistically insignificant (OR, 0.38; 95% CI, 0.03-5.3; $P = .42$), with too few observations to examine other ethnic groups. No differences were found for boys.

Safety

We examined measures of extreme dieting behavior at both the baseline and follow-up periods to assess whether the intervention could have produced unintended side effects. Overall, students in the intervention and control schools reported similarly low levels of extreme dieting behavior at both baseline and follow-up measurements.

COMMENT

Planet Health is, to our knowledge, the first randomized controlled field trial of a school-wide program specifically aimed at reducing obesity among middle-school youth. Study results indicate success in reducing obesity among girls, with no significant differences observed among boys. Reductions were found in students' television viewing time as a result of Planet Health for both boys and girls, and girls in the intervention schools experienced increases in fruit and vegetable consumption and a reduced increase in dietary energy intake over the 2 school years. Among girls, reductions in television viewing time predicted reductions in obesity, mediating the intervention effect and providing evidence for this causal pathway.

The lack of an intervention effect among boys suggests that different causal factors may operate among boys and girls, although there is little published scientific evidence to support this hypothesis. Alternatively, girls could be more attuned to issues of diet and activity and thus

Table 3. Estimated Differences in Change in Behavioral Variables From Baseline to Follow-up for Children in Planet Health Intervention vs Control Schools, 1995 to 1997*

Measure	Sample	Baseline†	Follow-up†	Crude Change‡	Adjusted Difference‡	95% Confidence Interval	P
Girls							
Total television/video, h/d							
Control	304	3.10	2.99	−0.11	−0.58	−0.85 to −0.31	.001
Intervention	289	2.98	2.28	−0.70			
Moderate/vigorous activity, h/d							
Control	304	1.67	1.74	0.07	0.36	−0.63 to 1.35	.43
Intervention	291	1.76	1.87	0.11			
Total energy from fat, %							
Control	285	31.0	29.8	−1.2	−0.67	−1.43 to 0.09	.07
Intervention	282	31.2	29.4	−1.8			
Fruit and vegetables, servings/d							
Control	284	4.1	3.9	−0.2	+0.32	0.14 to 0.50	.003
Intervention	280	3.4	3.6	+0.2			
Total energy intake, J/d							
Control	285	8122.8	9009	+886.2	−575.4	−1155 to 0	.05
Intervention	282	7526.4	8156.4	+630			
Boys							
Total television/video, h/d							
Control	319	3.78	3.43	−0.35	−0.40	−0.56 to −0.24	.0003
Intervention	313	3.73	3.03	−0.70			
Moderate/vigorous activity, h/d							
Control	319	2.47	2.44	−0.03	−0.40	−1.00 to 0.20	.16
Intervention	314	2.54	2.44	−0.10			
Total energy from fat, %							
Control	296	31.5	30.5	−1.0	−0.31	−1.10 to 0.48	.38
Intervention	296	32.0	30.5	−1.5			
Fruit and vegetables, servings/d							
Control	296	4.1	3.6	−0.5	0.18	−0.21 to 0.56	.31
Intervention	297	3.8	3.6	−0.2			
Total energy intake, J/d							
Control	296	9445.8	10 147.2	+701.4	−466	−1094 to 164	.13
Intervention	298	9361.8	9815.4	+453.6			

**Restricted to cohort students with paired data. Sample sizes vary due to missing data.*
†Baseline and follow-up values are the unadjusted means.
‡Adjusted difference represents the difference in change in scores in the intervention group compared with the control group, after adjustment for baseline value of the dependent variable, intervention status, randomization pairs, ethnicity, and baseline measures of obesity, triceps skinfolds, and body mass index. Regression estimates were calculated using SUDAAN software to account for cluster randomization.

more responsive to the intervention.[73] We found a similar prevalence of reported extreme dieting behavior among both boys and girls, as noted in prior studies,[65,74] although boys are much more likely to report trying to gain weight and girls to report trying to lose weight.[65] We found no evidence for increases in extreme dieting behavior among boys or girls, indicating that the intervention was not having this unintended side effect.

The behavioral data validate the potentially important role of television viewing time in changing obesity, as suggested by both prior epidemiologic research[8-11] and experimental results based on behavioral-choice theory.[25] These results indicate that a focus on reducing television viewing time can be a useful addition to intervention efforts.

The intervention also appeared to reduce the increase in energy intake among girls. The magnitude of the effect observed (−575 J/d; 95% CI, −1155 to 0 J/d), controlling for nonbasal energy expenditure (activity), is enough to influence obesity over the course of a year. The estimated mean intake among girls in the intervention schools (8156.4 J in 1997) is consistent with recent national estimates in this age range.[75]

While the analysis of obesity incidence and remission indicates statistically significant intervention effects only for remission, it is important to note that over this 21-month period only 33 incident cases occurred—13 among intervention girls—which limited the statistical power of our study to detect differences. Our finding of a significant effect on remission of obesity indicates that intervention effects may be largest among those most at risk for obesity.

This intervention study had several limitations. At baseline, the participation rate of students was 65%, due in part to lower rates of participation for students whose schools required active (written) consent; however, there were no differences in participation between intervention and control schools, and baseline data revealed similar characteristics of students in the intervention and control groups as well as similar follow-up rates in both groups.

The randomization of students was limited to randomization by schools (the clusters), increasing the risk of an unbalanced design and allowing the possibility for clustering of outcome observations within schools. The cluster randomization produced very comparable intervention and control groups, and outcome analyses took the clustering into account in estimating differences among intervention and control schools, using the generalized estimating equation and SUDAAN estimation approaches.[67,68]

A methodological concern was the potential for measurement error in the assessment of obesity. We used a composite indicator that should minimize errors and found no evidence for bias due to measurer variability. We were unable to adjust for maturation in boys but found no evidence for differences in variables associated with maturation in intervention students vs controls.

Another measurement concern is the limited validity of measures of dietary intake and physical activity based on self-reports. Our evaluation shows significant changes in television viewing, an increase in fruit and vegetable intake, and a smaller increment in total energy intake among girls in intervention schools compared with control schools. Are changes in these variables entirely responsible for the intervention effect? Our analyses indicate this was not the case; controlling for changes in these variables only marginally reduced the OR that indicated an intervention effect, signaling that either better measures of these variables or other variables were responsible for a substantial portion of the intervention effect.

Finally, further research is needed to evaluate the extent to which these changes persist over a longer period.

CONCLUSION

The Planet Health intervention decreased obesity prevalence among female students over 2 school years. The success of this program implemented in public schools by regular classroom and PE teachers indicates a promising approach to reducing obesity among youth.

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